THE PAPATACI FLIES (*PHLEBOTOMUS*) OF THE MALTESE ISLANDS*

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(PLATES V—VII.)

(*A report of the twenty-third Expedition of the Liverpool School of Tropical Medicine.*)

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Acting under the instructions of the Liverpool School of Tropical Medicine I proceeded to Malta on the 25th of June, 1910, and stayed in the Island for a period of two months. The object of this expedition was to investigate the problems connected with the menace to health caused by the blood-sucking 'Papataci Flies' of the genus *Phlebotomus*. † The greater part of my time was devoted to searching for the breeding-places of these insects with a view to devising practical prophylactic measures for the control of the pest. Other phases relating chiefly to the bionomics of *Phlebotomus* were also investigated; and attempts were made to rear the insect from the egg.

On making a critical examination of the material collected during the first week of my visit, two distinct species (*P. papatasii*, Scop., and *P. perniciosus*, n. sp.) were found to be almost equally abundant; and examples of a third, though apparently rare, species (*P. minutus*, Rond.) were subsequently taken. Since my return to England, Captain P. J. Marett, R.A.M.C., has very generously placed the whole of his collection of Maltese Papataci flies in my hands for examination and report; and among the numerous examples there were two specimens which have proved to be a new and hitherto undescribed species (*P. nigerrimus*, n. sp.), so

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† These insects are generally known to Englishmen as 'Sand Flies.'

that altogether four distinct species of *Phlebotomus* are now known to occur in the Maltese Islands.

These discoveries, though of much interest for the zoologist, add considerably to the labours of those who are or may be engaged in studying these insects more especially from a medical point of view; as owing to the minute morphological differences which exist between the females of these small midges the task of separating the respective species, more especially the commoner ones, is one which can be accomplished only after long and careful microscopical examination and comparison.

Hitherto the only species recorded from Malta was the common and widely distributed *P. papatasii*; but judging from recent experience, I have come to the conclusion that the almost equally abundant *P. perniciosus* must have been seen, though not recognised, by those who have been engaged in studying the bionomics of these insects.

It is highly probable too, that examples of this species were also used by those who conducted the transmission experiments, and although one has no direct proof, it is possible that *P. perniciosus*, like its near relative (*P. papatasii*), may also act as a carrier of Papataci fever.

THE SEARCH FOR BREEDING PLACES OF PHLEBOTOMUS

The results of my unremitting search for the breeding places of these insects were that I secured two larvae from the crevices of the loose rock in the 'caves' or catacombs at Notabile near the centre of Malta; thereby confirming the discoveries made by Captain Marett[6]* a month or so previously. Had my searches been continued in the same kind of habitat I have reason to believe that a few more larvae would have been secured, but having trained the eye so as to facilitate the finding of so minute an object the more readily on any future occasion, I proceeded in other directions, and searched innumerable places that were thought likely to form suitable breeding grounds for these insects, unfortunately without discovering either eggs, larvae or pupae; disappointment met me at

* Such numbers refer to the bibliography on page 181.

every turn and I am therefore unable to add anything that is new or noteworthy regarding the breeding places of *Phlebotomus papatasii* or any of the allied species.

In addition to the cave from which larvae were secured I also inspected the places in which both larvae and pupae had been found by Captain Marett; these were the cave at Gozo, the embankment forming part of the Cottonera Lines, and the stone wall in Captain Marett's garden, which he had thoroughly explored and had also kept under close and constant observation for a considerable time. In all of these places the conditions were very similar, if not almost identical.

In the caves the larvae occurred in the crevices and fissures beneath the loose rock amongst the damp earth, etc., at some distance from the surface, and I was informed that those which were found in the stone wall, occurred low down near the foundations, well within the centre, and attached chiefly to the under surface of the stones; while those from the Cottonera embankment were found at some considerable distance from the surface, where the stones were damp[6].

The crevices between the loose rock in the caves were often found partly filled with soil rich in organic remains. In the caves at Notabile, in which the larvae were found, the soil had for the most part been reconstituted by the burrowing larvae of various insects and other allied animals. To such an extent had this been done in some instances that quite 50 per cent. of the deposit consisted of the rejectamenta of insects, woodlice (*Oniscus* sp.), etc. Here and there were found also large numbers of the empty pupae of *Stomoxys calcitrans* and the pupae of other Muscid flies whose larvae had matured in the stable refuse which had been stored in the cave for agricultural purposes.

In all of these places the conditions were practically the same, the three main factors being: (*a*) the presence of organic matter; (*b*) moisture, but not in excess; and (*c*) the absence of light.

The principal places which were searched as being likely to afford suitable breeding-grounds for Papataci flies were as follows: The main sewers and ventilating shafts in various parts of the city of Valetta; drains of various kinds, cesspools and latrines in many places; cellars and prison cells in the Police Court; sewage works,

and the dark damp buildings used by the Customs as bonded stores; refuse of all kinds, especially such as occurred in dark damp places; the refuse 'tips,' and the roots of plants along the coast, especially in localities which were known to be badly infested with the flies; the decayed stems of the Prickly Pear (*Opuntia* sp.); collections of stone and rock in shady places in gardens and elsewhere; freshly excavated earth and rock; the empty shells of molluscs (chiefly *Helix* sp.) found in caves and other sheltered situations; refuse in caves which were used as stables for oxen and other domesticated animals, and the faecal matter which was found in those which had been used as latrines; the roots of trees, ivy and flowering plants which were kept moistened by constant supplies of water, also those growing in the rock fissures; the accumulation of leaves in damp places, etc.; litter from rabbit-hutches, consisting chiefly of faecal matter, especially at Casa Leoni, where the adult flies were invariably found associated with these animals.

Although one failed to discover either larvae or pupae in any of these situations, it does not prove conclusively, in my opinion, that these insects do not breed in some of them, especially as Grassi[3] has found that in Italy the larvae of *P. papatasii* live in dark damp spots amidst all kinds of refuse in underground places such as cellars, and particularly on the sides of drains which are kept moist by occasional splashes of dirty water.

Other investigators in Malta have met with results similar to my own. Lieut.-Colonel C. Birt, R.A.M.C.[2], who collected the most varied materials, states that he did not succeed in detecting the ova or larvae in any of the samples, 'nor has the adult *P. papatasii* ever hatched out from larvae which might have been hidden in the materials.' Captain Marett[6] has also made extensive search for the larvae and pupae in similar places and in similar materials, and has failed to find a single example of the insect in any of its stages. In so far therefore as our present knowledge is concerned, the only conclusion which can be drawn from the investigations in Malta is that the chief breeding-places of the Papataci flies (*P. papatasii* and *P. perniciosus*) are the crevices between the loose rocks in caves, stone walls, bastions and similar situations.

The task of finding such minute objects as either the larvae or

pupae of these flies is, however, very great; of the two, the larvae are perhaps the more conspicuous, but these have the remarkable habit of flicking themselves from off the surface of the stone or other objects when exposed to light, and in this way numbers may escape detection even under the most practised eye. The pupae are the more difficult to detect, as, apart from their minute size, the colour so exactly harmonises with the colour of the rock to which they are attached that they are rendered almost invisible, and when detected appear only as a naturally formed granular projection on the surface of the stone. In every sense, therefore, they are highly protective forms, and numbers must necessarily escape detection, more especially when artificial light has to be employed in searching for them. Bearing these facts in mind, large quantities of detritus were collected from many and varied sources so that it could be examined under more favourable conditions, but in no single instance were these insects found in either of their preliminary stages, though a lens of low magnification was almost invariably employed in searching for them. Quantities of the detritus were also kept in large vessels in the hope that adult flies might be successfully reared from it; in this again complete failure was the result. As to the detection of the ova in a state of nature I believe this to be a practical impossibility, as when laid upon dark substances they become absolutely invisible and can be detected only by the aid of a microscope. Even when laid in captivity in confined areas they are most difficult to detect, and under the most favourable conditions can be seen only when laid upon colourless or transparent surfaces such as white paper or the surface of a glass tube.

HABITS AND OCCURRENCE OF THE ADULT FLIES

Though so evasive in their early stages, the adult flies may be found almost everywhere throughout the Island in favourable situations or localities. They outnumber the mosquitos, and the females may be included among the most vicious of all the blood-sucking Arthropods. They are distinctly 'domestic' in their habits and may be considered among the most detestable of all man's 'uninvited guests.' It is a curious fact, however, that they

have their likes and dislikes both in regard to hosts and habitats. I can fortunately place myself among the small numbers of those who have proved immune to the bites of these blood-sucking pests; or at least I have never consciously experienced the effect of their bites, any more than I have in the case of *Pulex irritans*. And this is all the more extraordinary because fresh comers to the Island, especially children, generally suffer torture from the bites of these insects, and many cases are admitted to the hospitals through the infection which the Papataci flies are known to convey. To say the least, they are an intolerable nuisance in every part of the world in which they are known to occur. Man is evidently not the only vertebrate which these insects attack, as examples were frequently found which had filled themselves to repletion with the blood of the domesticated rabbit; so that it is evident that they are not entirely dependent upon man for food, and the probabilities are that they subsist and flourish on any of the warm-blooded animals when man is not available.

My experience with regard to the favoured haunts of these flies is almost precisely the same as that of other investigators. In certain parts of the island they were found to be abundant, while in others, for some unaccountable reason, they occurred very sparingly, though the conditions necessary for breeding purposes, especially stone walls, abounded everywhere. In badly infested regions, too, they favoured certain dwellings much more than others; of two houses occupying the same aspect and surroundings, or a section of the same block or street, one was often found to be infested while the other was rarely visited. It was noted also that there was a marked domiciliary distribution in many houses. Bedrooms on the first floor, especially those occupying a position on the lee or sheltered side of the house, were particularly favoured, while those on the opposite side of the building were rarely visited; and rooms at a greater elevation (second floor), which I had under close observation for a considerable time, were only once found to contain a single example.

The naval and military camps at Ghain-Tuffeiha afforded also a remarkable instance of the local distribution of these flies, the naval camp on one side of the plain being badly infested, while the other and more extensive camp was said to be practically free

from the invasion of *Phlebotomus*. This remarkable localisation was in all probability due to the fact that the naval camp was bounded on one side by rocky ground and stone walls, affording excellent breeding-grounds for the flies, while the military camp was remote from such surroundings, and lying fully exposed in the open plain.

At times also, when Papataci flies were literally swarming in houses near the old bastion at Floriana, not a single individual was discoverable in the city of Valetta, half a mile away. In this instance also one may safely infer that the flies at Floriana were breeding in close proximity, and it is highly probable that the actual site was in the interstices between the masonry forming the old fortifications, only a few yards distant from the dwellings.

The daylight retreats of these flies were often similar to those in which they were found at night, providing always that there was an absence of direct light. Thus in the dwelling-houses and barracks, the flies were found at rest in the dark corners of the rooms, under garments, behind pictures and in other similar places; but in nearly all cases they occurred in considerably smaller numbers than at night, though there were one or two noted exceptions. In one instance they could be found in considerable numbers in a badly lighted bedroom at any time of the day, especially after a still, damp night with a heavy sirocco. Odd examples were also found in cellars and in the prison cells in the heart of Valetta; while numbers could be found almost at any time in the small caves or isolated catacombs at Notabile, and such retreats seemed to be one of their favourite haunts during the day. In the early mornings, shortly after daylight, examples of both sexes may frequently be found inside the mosquito curtains, and after favourable nights they sometimes get entrapped in large numbers by this means. On the slightest disturbance the males may readily effect their escape through the meshes of the net; but the females, which are generally engorged with blood, are, under such conditions, much more sluggish than at other times and may then be captured with comparative ease, as they cannot escape through the net very readily when the body is distended with food. In one or two instances Papataci flies were dislodged from the interior of stone walls by forcing tobacco smoke into the interstices; but one met

with such little success that this method was abandoned. Sections of the lower portions of stone walls were also covered with chiffon and carefully examined at intervals during the night, and although the most favourable structures were selected for the purpose, and areas 36 square feet in extent were most carefully covered, not a single fly was entrapped by this method. This is all the more strange seeing that Captain Marett has met with marked success by adopting the plan even on a smaller scale. However this may be, it is perfectly obvious that in the light of Captain Marett's experience stone walls, especially those from which the surface 'pointing' has fallen away in patches, leaving free access to the interior, are the frequent and possibly the principal resorts of the parent flies.

Atmospheric conditions have undoubtedly a marked effect upon the flies. On still sirocco nights they take wing freely and occur in dwellings in larger numbers under such conditions than at any other time. On the other hand, when fresh cool breezes are blowing, especially from the north-west, they are rarely seen; and it is the testimony of everyone who has studied their habits that these insects remain in their hidden and sheltered retreats and rarely venture forth at such times. There is little wonder at this, as their frail bodies and delicate wings are ill-suited for flight under such conditions; moreover, it is a habit common to many members of the same order; minute midges, in particular, are often seen to swarm on still warm evenings, and rarely if ever assemble in numbers under any other circumstances.

A general belief is held by the Maltese that certain kinds of trees and shrubs (fig and loquat especially) form the principal resorts of these insects, and many are also under the impression that they breed either in the foliage or branches or in the fallen and dead leaves which lie beneath them. There may of course be a measure of truth in these theories; but we may at once dismiss the statement that they breed in the trees. It is perfectly obvious, however, that the presence of ornamental shrubs and fruit trees in the walled-in gardens would afford them just the kind of shelter and shade which they require, and would enable them in all probability to travel the more safely from their breeding-places to the house in the immediate vicinity. It is just possible that rotting vegetation in

damp shady places, such as shrubberies, may form a breeding-place also, but so far as our researches have extended up to the present moment we have no evidence in support of this view. Considerable attention was paid to searching such materials but with negative results, as has already been stated. It is clearly evident moreover that dry materials, whether in a state of decay or otherwise, do not form a suitable breeding-place, especially dead leaves which may accumulate on the surface of the ground beneath the trees; light and dryness being both unsuitable conditions for the preliminary stages of the *Phlebotomus*.

The characteristic attitude of *Phlebotomus* is portrayed on Plates VI and VII. When at rest the wings slightly diverge and are elevated at a considerable angle above the thorax and abdomen. On the least disturbance the insects make short rapid flights, almost invariably to the right or left, reminding one of the rapid movements of a flea rather than those of a winged insect. Occasionally, however, they will take long-continued flights, when the course is more or less direct and distinctly midge-like. Their movements on the wing can be followed with little difficulty in daylight, but by artificial light it is almost impossible to do so for more than a few seconds at a time.

Both sexes live but a short time in captivity, unless they are fed upon human blood. Without this they will subsist on wet blotting-paper or other damp materials, such as soil, fresh leaves, etc. Under such conditions many examples survived for periods varying from three to nine days though the majority died on the third and fourth days, even although the females, in many instances, had taken a meal of blood a few hours before they were captured.

SEASONAL PREVALENCE

The adult insects were more or less prevalent during the whole of my stay in the island (July, August, and the first week in September). That the numbers fluctuated during this period has already been mentioned, but this was apparently due, in a large measure at least, to variations in temperature, humidity, and wind. Relatively few Papataci flies occur before the middle of June, and

practically all observers of their habits informed me that they occur most freely and are most troublesome during the hot, dry months of the year. It is highly probable that successive broods are produced during the summer months, but as the larval stage occupies apparently a long period, the successive generations can be produced only at extended intervals.

As to whether the larvae occur most frequently during the summer remains to be seen. It is my impression, however, that they may be found more abundantly in autumn and winter than at any other season, and careful search should be made for them a week or so after the adults have disappeared.

PROPHYLACTIC MEASURES

In consideration of the facts which have so far been brought to light regarding the economy of *Phlebotomus*, it is clearly evident that the task of suppressing these insects is an almost insurmountable one. Had we to deal with insects as large and as accessible as mosquitos, the adoption of prophylactic measures would be comparatively easy, but owing to the extremely minute size and almost flea-like habits of the adult insects, and the enormous area over which the breeding-places may occur, we are faced with a problem which is most difficult of solution.

As I was unable to devote any time to experimental work bearing upon the control of these pests, the only course open to me now is to suggest a few measures which may ameliorate the existing conditions and lead to a reduction of the malady of which these insects are transmitting agents. It seems to me, however, that the only practical way of grappling with this question is to proceed tentatively at first, and although I have discussed an extensive field of operations which may be directed against these insects, I would pin my faith rather to some of those measures which are considered under the following headings. But in the first instance it must be borne in mind that precautions against the bites of blood-sucking insects, though feasible to intelligent and well-to-do persons, are not as a rule employed by the mass of the people. Yet any prophylactic measures which are calculated to diminish the infection, even in a small degree, should be seriously and persistently employed.

Repellents.—I had no opportunity of demonstrating the value of these by experiment owing to my immunity from the bites of these insects, but I was assured that several good formulae were in general use, though proprietary preparations were rarely employed. Judging by the testimony of those who had used such deterrents, one of the best was that which was prescribed by Major Crawford, R.A.M.C., and I am extremely indebted to him for giving me permission to embody it in this report. It is composed of the following ingredients:—

Ol. Anisi, one drachm.

Ol. Eucalypti, one drachm.

Ol. Terebenth, half a drachm.

Unq. Acid Borac, one ounce.

Spraying with repellents.—The least objectionable of these, and at the same time one of the most effective, is formalin. The dark portions and angles of sleeping apartments should be sprayed with a 1 per cent. solution of this substance every day during the season in which the flies are prevalent; a fine spraying apparatus is necessary for its application, and an excessive amount must not be applied. It is considered an excellent plan also to spray the mosquito curtains regularly every day towards sunset; nets thus treated are claimed to repel the attacks of these insects.

Fumigation.—There are several substances which are employed as fumigants for the destruction of insects, but I fail to see the practical utility of employing such means for the destruction of Papataci flies in Malta or elsewhere.

Light.—Daylight is a most important factor in driving away these insects from man's dwelling-places, and directly a flood of light is admitted to a room in which Papataci flies may be present, they immediately seek places of concealment behind garments or draperies and pictures, or other furniture which may be suspended from the walls or placed in dark corners. It is important, therefore, that as much light should be admitted into the rooms as is possible, and this can easily be done either in the early morning or evening, or when the windows are lying in shadow.

Beds should be arranged in the best-lighted portions of the

room, and on no account should children's cots be placed in out-of-the-way corners in deep shadow. Decorative drapery in such apartments should be abolished, and the walls rendered as free from pictures and other furniture as possible.

Artificial light does not, unfortunately, act as a repellent; on the contrary, it would appear to serve as an attraction for these insects, as it is well known to do with other groups belonging to widely different orders.

Artificial air movement.—In India, if not also in other parts of the tropics, it is a recognised fact that punkahs and fans will repel the attacks of mosquitos if continuously and properly employed. It seems to me, therefore, that if a similar method could be applied in Malta, we should be able to dispense with almost every other form of prophylaxis which is discussed in this report. As it has been abundantly proved that Papataci flies do not take wing when the slightest breezes are blowing, one may safely infer that they would not face a strong current of air such as would be produced by either fans or punkahs. It is unlikely that the latter will ever be employed in Malta, but it is my firm belief that if electric fans were fitted so as produce a current of air in the direction of the window in sleeping apartments, that very few, if any, of the flies would be able to pass through the open window into the room beyond. I venture to recommend, therefore, that this method be put to the test, and if found to give satisfactory results, that it be employed in all cases where the cost of running such an apparatus is not a serious consideration.

Traps.—If a modified form of the biscuit-box trap, such as is used for capturing mosquitos, were fixed high up in the dark corners and angles of the rooms, I believe that numbers of Papataci flies would be entrapped. The trap should be made in the form of a corner-cupboard in miniature, and should measure about eighteen inches in length; the basal portion should be left open, and the interior should be lined with dark cloth or similar material. These should be examined daily and the flies killed with ammonia fumes.

Nets.—The use of ordinary mosquito nets is of no avail against the bites of these pests, as they readily pass through the meshes, and attack persons just as freely as if nets were not used; but if they could be rendered repulsive to the insects by spraying them

with formol or other repellents, as has been suggested, so much the better; but experiments in this direction must be conducted before we can say definitely that such a method would prove effectual. Fine nets made of strong chiffon or other similar material would undoubtedly prevent the approach of these flies, but the use of such nets would render sleeping almost impossible in the hot weather unless electric fans were used at the same time. If such preventive measures as these could be employed to the complete satisfaction and comfort of patients in hospitals, especially those suffering from the Papataci fever, or to the community in general we shall have succeeded in devising an excellent prophylactic measure. If a net of this type is used, it should have a strip of calico about two and a half feet in width stitched all round the bottom, so that at least twelve inches of it extends above the bedding, the remainder to be tucked in under the mattress. The use of this is obvious; the strip above the bedding would prevent the flies from biting any portion of the body which might be brought into contact with it, and the lower portion of it would stand the strain of 'tucking-in,' and consequently last for a very much longer time than such flimsy material as chiffon.

Destruction of breeding-grounds. — As to the operations necessary for reducing the number of breeding-places, it is perfectly obvious that we can never expect to be able to deal with these in any of the rural districts, owing to the fact that the fields and roads extending over the whole of the country are bounded by stone walls, and elsewhere there are fissured rocks, caves, and other suitable places which afford just the right conditions necessary for the breeding of Papataci flies. On the other hand, we may reasonably hope to reduce them in the principal centres of population, if persistent efforts are made to accomplish this, and if financial considerations do not prohibit the employment of such methods as are herein suggested. If it should be considered advisable to carry out any section of this part of the propaganda, one of the smallest and most isolated of the infested areas should be chosen as an experimental ground, and an officer who is thoroughly acquainted with the habits of the insects should be appointed to direct the operations. If loose rubble walls exist in the immediate neighbourhood of the selected area, these should be

either demolished and the materials removed, or they should be completely covered with a thick layer of cement.

If such a type of wall exists as has the jointings partly filled with plaster ('pozzolani'), then all openings and fissures should be carefully filled in with cement, so that no holes are left for the ingress or egress of the flies, remembering always that a crevice sufficiently large to admit a flea will also afford ample space for the admission of the fly.

If it should be found necessary to replace the old walls with new ones, it is imperative that these should be built of solid masonry to a height of at least two feet above the level of the soil on either side, as it is the lower portions of the walls that are, according to Captain Marett's experience, selected as breeding-places; but it would be better, in my opinion, to make all new walls of solid masonry from the foundation to the topmost course or layer; and if the old walls could be substituted by any other form of boundary, so much the better.

There are also other kinds of walls which may have to be dealt with, and these are they which form the old bastions and other extensive fortifications at Cottonera and elsewhere. In cases where such structures are backed with rubble and finally protected with loose rock, it would be a comparatively easy task to prevent the egress of the flies through such loose material by breaking or pulverising it, or by covering it with soil; but unfortunately the question of pointing the Ashlar work forming the facings of the bastions and curtains presents not only a serious financial difficulty, but a task which could be accomplished only by a huge army of men; and in consideration of these facts it seems to me that in the present stage of our inquiry such a method of procedure would be extremely unwise and irrational. For the time being, therefore, I should strongly advise that in selecting the experimental area a site should be chosen which is as remote from the old fortifications or similar structures as is possible.

Though there is no evidence which will lead us to believe that Papataci flies breed in the cellars and drains in Malta, at the same time we must not lose sight of the fact that Grassi[3], as has already been stated, has found larvae of *P. papatasii* in such places. It is highly probable, therefore, that this species breeds in similar

habitats in Malta also; but it is impossible without more study to make any definite statement on the point. Taking all the facts into consideration, therefore, I consider that the only really practical prophylactic measures which can at present be taken are those which are considered as precautionary against the bites of these insects. It is perfectly obvious, moreover, that any operations which will not bring about an almost complete destruction of the breeding-grounds are not likely to make an appreciable reduction in the numbers of these insects.

SYNONOMY, AFFINITIES, AND MORPHOLOGY OF THE GENUS PHLEBOTOMUS

Though the differential characters of this genus have been given by several authors, and Grassi[3] has published an elaborate memoir on the morphology and biology of *Phlebotomus papatasii*, I consider that this report would be incomplete without giving some details concerning the morphology of these insects; all the more so because Grassi's paper, in Italian, is now very difficult to obtain and also a very costly publication, in fact the price (£1 10s.) for so small a work, is practically prohibitive, and certainly not within the reach of students in general.

I do not claim, however, to treat of this phase of the subject in an exhaustive way, but rather to point out the salient characters of these insects in a measure that may be helpful both to the medical profession and to the zoologist.

The genus *Phlebotomus* was established by Rondani in 1840, though the species for which it was founded had been placed by various authorities in other genera, such as *Bibio* (Scopoli, 1786), *Musca* (Gmelin, 1788-1793), *Ciniphes* (Costa, 1840). But as Rondani's name is now generally accepted, one need not go into further details regarding the nomenclature and synonyms of *Phlebotomus*. The taxonomic position of this genus is with the family PSYCHODIDAE, and it is included in the sub-family PHLEBOTOMINAE. All the members of this family are small Nemocerous insects characterised by the possession of relatively large wings which are clothed with either scales or hairs; and one of the most familiar representatives, and one also which is widely

distributed and nearly related to *Phlebotomus*, is the genus *Psychoda* (sub-family PSYCHODINAE) the members of which are known generally to Englishmen as 'Moth-flies' or 'Owl-midges.' The short diagnosis which follows will serve at once to distinguish *Phlebotomus* from any of the allied genera in the PHLEBOTOMINAE and also from the midges belonging to the PSYCHODINAE.

Genus PHLEBOTOMUS, Rondani

Mouth formed for piercing and sucking; palpi of five segments; antennae long, filiform and composed normally of sixteen segments; wings hairy, narrow, second longitudinal vein twice forked, cross-veins placed near the basal fourth of the wing; body clothed with hairs; sexual dimorphism distinct.

The larva (Pl. V, figs. 7-8) is characterised by its caterpillar-like form (eruciform); by the presence of two pairs of long caudal bristles, which may equal the length of the body; and by the absence of true legs.

The pupa (Pl. V, fig. 12) is obtectate, and may be recognised by the presence of the larval skin which invariably remains attached to the last two segments of the abdomen. It should be borne in mind, however, that the partial retention of the larval skin by the pupa, is not peculiar to the genus *Phlebotomus*, as Speiser[8] has shown that the larval skin of *Helea* (*Forcipomyia*) *regulus*, Winn., one of the members of the CHIRONOMIDAE, also remains attached to the anal segments of the pupa. The larva of this genus does not, however, possess the long caudal bristles which are so characteristic of *Phlebotomus*, though in other ways it is not unlike the latter.

EXTERNAL MORPHOLOGY

Head (figs. 1 and 9) somewhat elongated, but distinctly narrowed at the nape, vertex clothed with long hairs; clypeus large and also clothed with hairs on the upper surface. Eyes large and intensely black.

Antennae (fig. 2) very long and slender, and in all of the Maltese species consisting of sixteen segments; the first and second segments forming the scape are short and stout, the second one

being somewhat spheroid in shape; the third is much the longest and of uniform width throughout; the remaining segments are gradually swollen proximally, especially the terminal ones; all are clothed with hairs; those arising from the swollen portions being much the longest and considerably longer than the individual segment to which they are attached. In all of the Maltese species there are also present on several of the segments, and in both sexes, *a pair of relatively large geniculated spines* (fig. 2). These curious

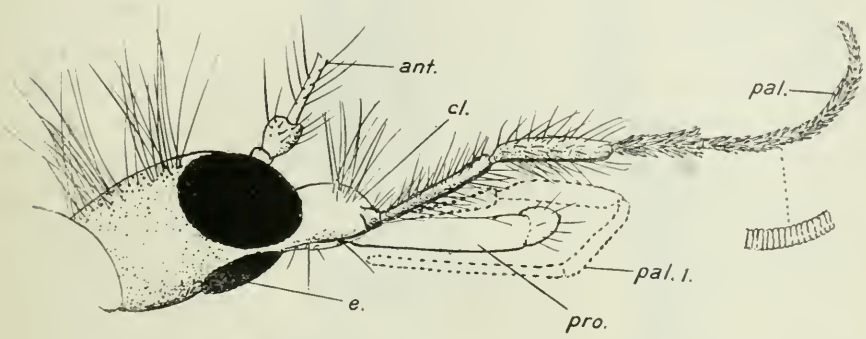

FIG. 1. --Head of *Phlebotomus papatasii*; *ant*, antenna; *e*, eye; *cl*, clypeus; *pal*, palpus; *pro*, proboscis.

appendages are rendered practically invisible when the segment to which they are attached is mounted so that a dorso-ventral aspect is presented under the lens of the microscope; and for this reason apparently they have been hitherto overlooked by all the students of this genus of insects. It is true that Grassi[3] (p. 12) has noted that 'here and there one can observe a short hair curved and relatively thick'; but that he failed to recognise the true character and arrangement of these spines is perfectly clear. Now that they have been discovered it is highly probable that they will be found to exist in the majority of species, if not in all, and may I think be considered of generic importance. Annandale, in his description of the genus *Brunettia*, a new Psychodid discovered in Southern India, refers to a similar character, but in this instance the paired spines are somewhat **S**-shaped and relatively much stouter than the corresponding spines in *Phlebotomus*. In the light of these discoveries, therefore, it is possible that similar spines may be discovered in various other members of the same family, though

it is highly improbable that such structures will eventually be found to exist in all of them.

Palpi (figs. 1 and 13).—These organs are generally said to be composed of four segments, but there are undoubtedly five, and

FIG. 2.—Antenna of *Phlebotomus papatasii*.

this number may, I think, be considered common to all the members of this genus. Annandale[1] has pointed out that 'a minute basal

joint can sometimes be distinguished in fresh specimens,' but that it is 'often difficult to see and appears to be imperfectly separated from the others.' That the small basal segment is clearly articulated to the second there can be no doubt, as it can be seen quite distinctly when mounted so that it is not obscured by the surrounding structures. All of the segments are clothed (in *P. papatasii* at least) with variously formed scales, intermixed with a few hairs. The scales on the first three segments are for the most part very long and somewhat hair-like, those on the remaining segments short and closely packed together. The fourth and fifth segments, especially the latter, are distinctly but somewhat irregularly annulated or ringed, a character which has also been hitherto overlooked by former investigators. In life, when these organs are at rest they are bent downwards and backwards at the articulation of the third and fourth segments, so that the anterior half of the palpus is folded back more or less upon the proximal half; by this curious arrangement practically the whole of the proboscis is covered or protected (fig. 1, *pal.* 1).

Proboscis (figs. 1 and 3).—Slightly shorter than the head, inclusive of the clypeus; in form it is somewhat cylindrical and slightly recurved distally. In the female it is composed of the following parts:—*The labium* (fig. 3, *lb*). This is much the largest organ, and as far as one can judge by viewing it in optical section, it almost completely embraces the labrum-epipharynx; the proximal half is sparsely clothed with lanceolate scales, and the first third is markedly narrower than the rest; immediately in front of the dark chitinous apodeme or sclerite is a curved row of long fine hairs; the labella are scarcely broader than the widest portion in the region of the apodeme, and are clothed with a number of fine and rather long hairs. *The labrum-epipharynx* (fig. 3, *lbr*) is relatively narrow and the sides are parallel, but the apex is suddenly attenuated the tip bluntly pointed, and the margins furnished with a series of long spinose teeth set closely together and numbering about twenty on either side; ventrally it is deeply and broadly channelled but does not appear to possess interlocking teeth or other structures. *The hypopharynx* (fig. 3, *hy*) is similar in width and general form to the labrum, but tapers off much more gradually towards the end, and the marginal

spinose teeth are much shorter and placed so closely together as to present a finely serrated edge; its upper surface is distinctly and broadly concave or trough-like and the salivary duct which is small, occupies a central position. *The mandibles* (fig. 3, *md*) are broad and blade-like, and have the outer edges faintly serrated, the

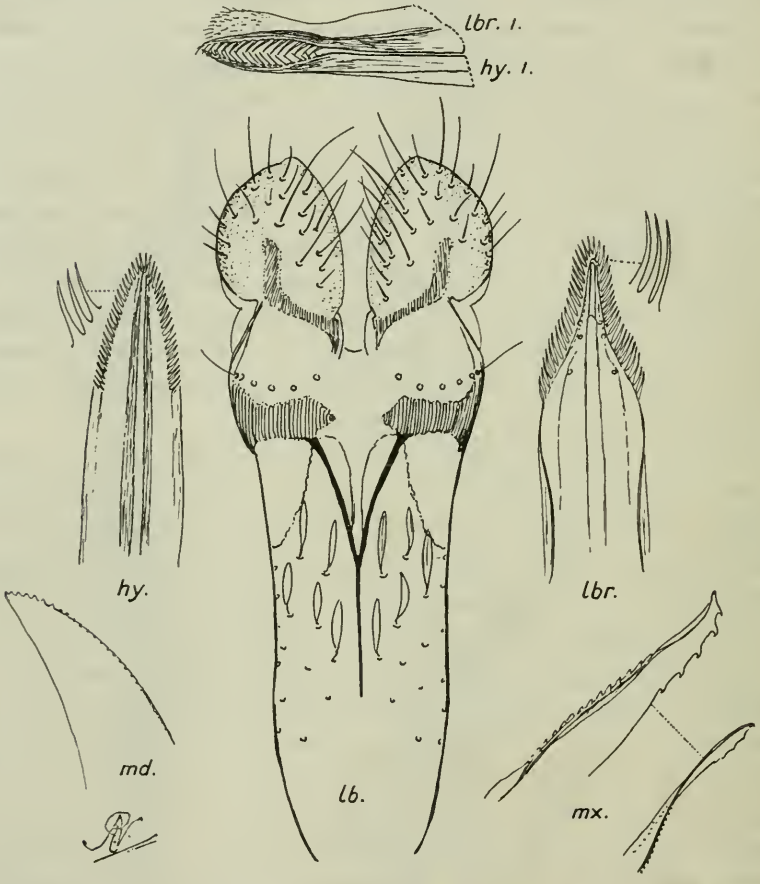

FIG. 3.—Mouth-parts of *Phlebotomus papatasii*, ♀; *lb*, labium; *lbr*, labrum-epipharynx; *hy*, hypopharynx; *md*, mandible; *mx*, maxilla.

The upper figure represents the labrum *(lbr* 1) and hypopharynx *(hy* 1); male, *P. papatasii*, as seen in profile.

serrations being rather widely separated. When at rest they lie, apparently, superimposed one over the other. *The maxillae* (fig. 3, *mx*) are much narrower than the mandibles, curved transversely, and attached to a broad trough-shaped sclerite, not to

a long slender stalk as Grassi has shown. One edge is provided with five relatively large and widely separated teeth; the opposite edge with smaller ones set closely together.

Thorax (fig. 8).—This consists largely of the meso-thoracic division, the prothorax being represented by a very short extension which can be seen more or less distinctly in examples which have been macerated and mounted in Canada balsam. The scutellum and post-scutellum are well developed and conspicuous in mounted preparations.

Abdomen.—This is composed of ten segments, the last being modified by the external genitalia. In the female the appendages are simple, flattened, leaf-like structures, densely clothed with hairs and arranged in two pairs (figs. 8 and 10). In the Maltese species they are all so similar in structure as to afford no diagnostic characters of importance. Annandale[1] states (p. 41) that these organs 'become distorted and shrivelled in dried specimens.' These structures can, however, be restored by maceration in caustic potash but the best results may be obtained by preserving the specimens in alcohol.

External genitalia of the males.—These are large and complex structures (figs. 14-18) and afford a ready means of determining the sexes, moreover, their morphological characters are of great importance as they present very marked specific differences whereby the closely allied species may be readily distinguished. These appendages are arranged in five pairs as follows:—*Superior clasper.* (*sc* in all the figures). These are placed dorsally and are larger than any of the other structures; they are composed of two distinct segments, of which the terminal or distal one is the smaller and is provided at the apex with large spines, which in some species are curiously modified. They are generally densely hairy and large scales may also be present; but both hairs and scales are easily deciduous and the greater portion of them usually fall away during the process of mounting for microscopical study. The accompanying illustrations must therefore be considered as representing these structures in a partly denuded condition. *Inferior claspers* (*ic*). These are unisegmented and much shorter than the superior pair; they are ventrally placed and may or may not have modified spines at the distal extremity. *Submedian*

lamellae These lie between the inferior claspers, and although they are usually short, thin, leaf-like structures, in some instances (*P. minutus*) they are very similar to the clasper both in form and length. *Intermediate appendages* (*ia*). These occupy a median position and are often curiously modified; they form a branch of the superior clasper and are sometimes bi-lobed. *Intromittent organ* (*io*). This is homologous with the 'juxta' in *Glossina*, and is described as the penis by Grassi. It consists of a pair of long slender and highly chitinised organs which lie between the intermediate appendages. These completely ensheath the two long filamentous processes which form a continuation of the ejaculatory duct leading from the penultimate segment of the abdomen. In *P. papatasii* they have not been seen to extend beyond the intromittent organ or penis, while in *P. perniciosus* (figs. 16, 17), though lying apparently in a normal resting position, they project beyond it to a distance equalling one-half the length of the sheath.

Wing.—This is densely hairy, and may at once be distinguished from that of the mosquitos (CULICIDAE) by the entire absence of scales, the double fork of the second longitudinal vein, and the proximal position of the cross-veins. The hairy character is well shown in the illustrations (Pl. VI, fig. 2, and Pl. VII, figs. 1, 2), and when denuded (figs. 4-7), the venation can be seen with little difficulty in properly prepared specimens. The costa is the thickest of the veins. The sub-costa, in comparison with that of the CULICIDAE, is very short, curves downward distally, and joins the first longitudinal vein at or about one-fourth of the distance between the base and tip of the wing. The first longitudinal is simple, and unites with the costa about one-third from the tip; the second longitudinal is twice forked, and extends almost to the base of the wing; the third longitudinal is simple, and originates from the mid cross-vein; the fourth has origin at the base of the wing and is forked near the middle; the fifth and sixth are simple and united basally, the former curving upwards and uniting with the fourth considerably in advance of the base of the wing. The first cross-vein unites the costa with the sub-costa at a point immediately opposite to the turned-down portion of the latter, so that in effect they produce two cross-veins: the first

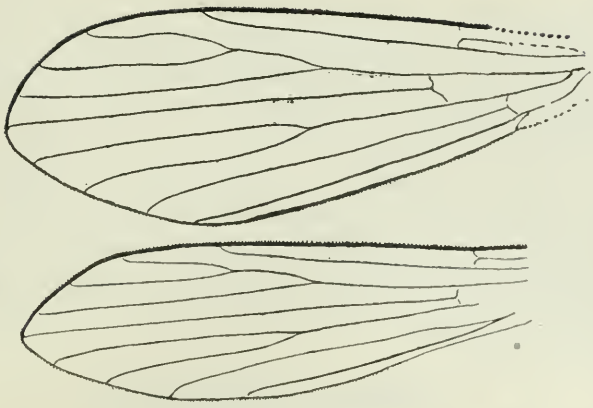

FIG. 4.—Wing-venation of *Phlebotomus papatasii*; upper, ♀; lower, ♂.

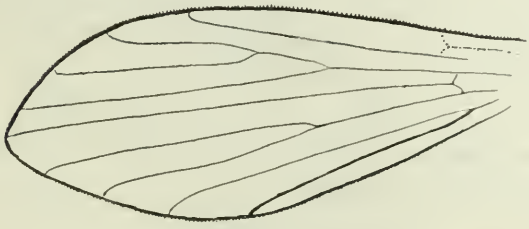

FIG. 5.—Wing-venation of *Phlebotomus nigerrimus*.

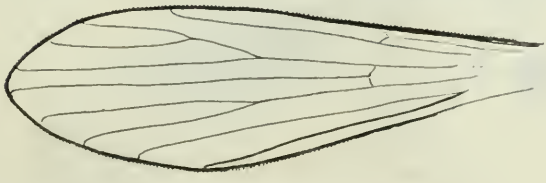

FIG. 6.—Wing-venation of *Phlebotomus perniciosus*.

FIG. 7.—Wing-venation of *Phlebotomus minutus*.

extending from the first longitudinal vein to the sub-costa, the second from the tip of the latter to the costa. The mid cross-vein arises from the base of the third longitudinal and passes obliquely to the fourth; while the supernumerary vein is placed immediately above it, and passes obliquely to the second longitudinal.

Legs.—These are very long and slender and densely clothed with scales, the majority of which are flat and closely resemble those which are found in the CULICIDAE. The ungues are simple in all of the Maltese species, and do not offer any differential morphological characters.

INTERNAL MORPHOLOGY

The Alimentary Canal (fig. 8).

This structure differs from that of the mosquito in having a true sucking stomach, and also in the possession of four malpighian tubules instead of five. The general form and relative position of these organs in the female are as follows:—

The buccal cavity lies at the base of the clypeus; it is dilated distally, but almost immediately contracts and forms a slender tube which leads to the pharynx.

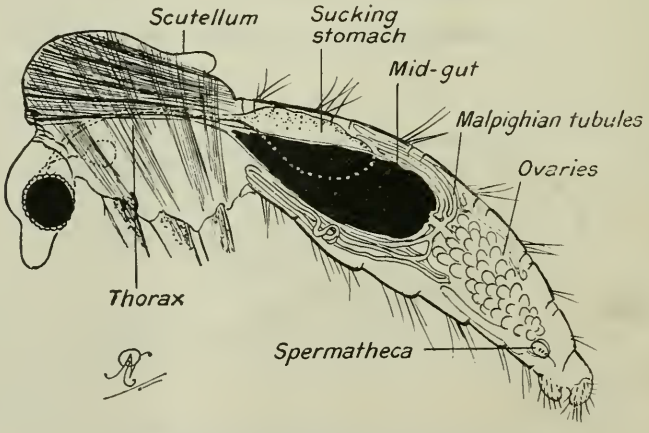

FIG. 8.—Internal morphology of *Phlebotomus.*

The oesophagus divides at a point a little in advance of the posterior margin of the head (nape), one tube leading to the sucking stomach, or food-reservoir, the other to the digestive canal.

The sucking stomach.—This is a large, thin-walled pouch, connected with the end of the oesophagus by means of a very slender tube. It lies on the left side of the digestive canal, and extends distally as far as the region of the fourth abdominal segment.

The mid-gut or chyle stomach.—This is capable of great distention, and when filled with fresh blood occupies a large portion of the abdominal cavity; but when such food has been partly comminuted it becomes much smaller, and can be easily seen as a black, elongated pouch in the anterior portion of the body.

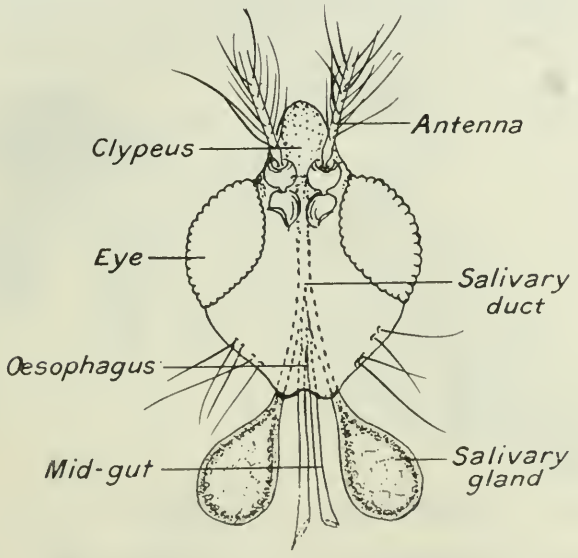

FIG. 9.—Head of *Phlebotomus*, showing position of salivary glands.

Malpighian tubules.—There are two pairs of urinary organs, each pair being united at their bases, where they form a single tube, which is connected with the intestine immediately below the mid-gut. They are of great length, extending forwards as far as the first abdominal segment, where they are folded and doubled backwards upon themselves, and also form loops in the mid-region of the ventral portion of the abdominal cavity.

The salivary glands (fig. 9).—These consist of two broadly dilated or lobe-like acinous glands, lying one upon either side of the prothorax. The periphery of these glands presents an even or

smooth surface, and immediately within the exterior wall is a series of rather large secretory cells. The ducts leading from the acini unite near the mid-region of the head, forming a common duct, which enters the buccal cavity close to the base of the clypeus.

The Sexual Organs of the Female.

The ovaries occupy a variable position in the different stages of their development. In the early adult stages of the insect (fig. 8) they are very small, and are seen to extend from just behind the origin of the Malpighian tubules to the region of the penultimate segment of the abdomen. When fully matured (fig. 10) they occupy practically the whole of the abdominal cavity, extending forwards

FIG. 10.—A female *Phlebotomus*, showing fully matured ovaries.

as far as the second segment. They are bi-lateral, and each ovary comprises 20-25 ova, representing a full complement of 40-50, so that these insects cannot be considered very prolific. The tubular oviducts unite at a point just before reaching the base of the inferior claspers, where they form the common oviduct.

The spermathecae (fig. 11) lie in the median line in the region of the oviducts. They consist of a single thin-walled, sub-spherical sac, and are relatively very large; at their junction with the duct they are strongly chitinised, and consist of usually ten transverse and convex ridges, which are so constricted at the margins as to present, in optical section, a distinct and well-marked crenulation. The tubular ducts, which are long and straight, open into the oviduct near to its termination, apparently.

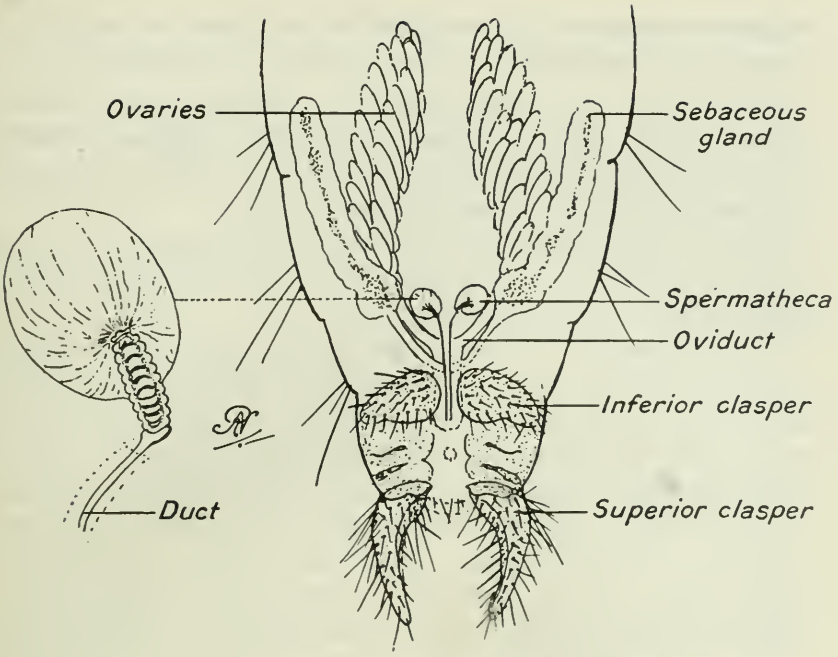

FIG. 11.—Female generative organs of *Phlebotomus*.

Sexual Organs of the Male (fig. 12).

The external characters of the male armature or copulatory apparatus have already been discussed (p. 159) and although the internal sexual organs have been but briefly studied, from

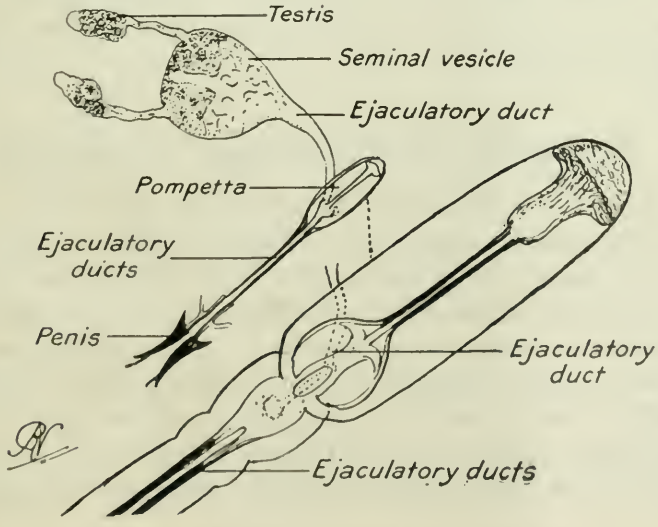

FIG. 12.—Male generative organs of *Phlebotomus*.

preparations examined in optical section, yet a brief account of them may not be without interest. These consist of the following:—

The testes.—These may present a somewhat variable outline, though normally they are elongate-ovate; they are distinctly paired and widely separated, each possessing its own duct which enters the seminal vesicle at its anterior lateral margin.

The seminal vesicle consists of a large pyriform sac, the proximal portion of which gradually narrows and merges into the short, tubular, ejaculatory duct.

The ejaculatory duct is connected with a singular morphological structure which, together with the chitinous rods, presents a slender and somewhat club-shaped though cylindrical process. The outer wall of the swollen portion is formed of thin transparent chitin; and occupying a central position is a piston-like rod which is dilated at both extremities; the distal portion somewhat resembles an inverted bulb, the opposite dilatation forming a more or less spherical sac. The space between the central structures is seen to contain delicate muscular fibres; and the ejaculatory duct leads into the spherical cavity at the lower end of the piston-like rod. Grassi's interpretation of the mechanism of this structure is that it acts like a little pump (*pompetta*) and regulates the exit of the spermatozoa. Beyond this structure the ejaculatory duct is protected by two slender hair-like rods which are highly chitinised and form the 'intromittent organ' which has already been described (p. 160) as extending into and in some cases considerably beyond the penis-sheath or juxta.

OVIPOSITION OF PHLEBOTOMUS IN CAPTIVITY

The act of oviposition was observed on several occasions and was not without interest, as the insect assumed a position which seemed altogether unique and extraordinary. In the first instance, a female with ripe ova was placed in a small glass-topped box, the bottom of which was within focal distance of a lens magnifying eight diameters. She was supplied with blotting paper which had been soaked in clean water. On placing this in the box the insect immediately alighted upon it, brought her proboscis into contact with the paper, and after a few seconds appeared to be perfectly

intoxicated and helpless. Unfortunately she struggled away and was finally hidden beneath the paper so that further observations at the time were impossible. After an interval of a few minutes she reappeared, crawled up the side of the box, and one and a half hours later seemed as active as when first captured. On the following day, at 9.30 a.m., a fresh supply of wet blotting paper was placed in her cage when in less than sixty seconds she alighted upon it and assumed the same extraordinary attitude as on the previous evening at 6 p.m., collapsing immediately and placing her legs so that the middle and hind pair were crossed behind the abdomen, the front pair remaining almost in a normal position. The abdomen was then elevated and extended to the full and three eggs were laid at short intervals. Each egg appeared under the lens as a tiny translucent drop of fluid and was ejected with considerable force to a distance equal to about three times that of the length of the abdomen. This process lasted for about two minutes, and afterwards the female crawled slowly away and up the side of the box, appearing weak and fatigued. Here she remained almost motionless for nearly three hours, gradually raising the whole of the body until it assumed a normal resting attitude.

On removing the blotting paper which had been placed in the cage the previous evening, seven additional eggs were found and these were evidently laid the previous evening when the insect was observed to go through the evolutions which have just been described. At 12.30 a.m. the same day she repeated the process when freshly moistened blotting paper was supplied. On this occasion two eggs were laid and these were found attached together side by side. At 5 p.m. two additional eggs were laid, the same curious attitude being assumed as before, but although frequently supplied with fresh wet blotting paper she did not produce any more eggs, and at 10 p.m. she died. On making an examination of the abdomen it was found to contain eight fully developed ova so that it is quite evident that this female had laid eggs elsewhere and previously to her capture.

The act of oviposition was seen on subsequent occasions, but in two instances the females died after remaining in a collapsed condition for periods of two and a half hours, and three hours and three-quarters, respectively. Both examples had their abdomens

well filled with ripe ova and had apparently not laid any eggs before they were captured.

Synopsis of Maltese Species of Phlebotomus

A. Abdominal hairs recumbent.

(*a*) Integument black. Large species. Palpi with second segment slightly longer than the third.

nigerrimus, n.sp., p. 168.

(*b*) Integument ochreous. Small species. Palpi with second segment one half the length of the third.

minutus, Rond., p. 169.

B. Abdominal hairs more or less erect.

(*a*) Legs in both sexes relatively short; average length of hind leg, 3 mm. Terminal segment of superior clasper of male scarcely half as long as the inferior clasper.

perniciosus, n.sp., p. 172.

(*b*) Legs in both sexes relatively long; average length of hind leg, 4 mm. Terminal segment of superior clasper of male slightly longer than the inferior clasper.

papatasii, Scop., p. 174.

PHLEBOTOMUS NIGERRIMUS, n. sp.

Female.—*Colour.* Head, thorax, and abdomen brownish black; hairs bright ochreous buff, those on the thorax being slightly paler and erect, those on the abdomen recumbent. Basal segment of antennae dark brown. Palpi pale to dark brown, hairs similar in colour to those on the body. Legs pale ochreous buff, with ochreous white, *not silvery white*, refulgence. Wings ochreous buff or dull golden in some lights.

Head. Proboscis long; eyes black, deeply emarginate in front. *Palpi* and *antennae* very like those of *P. papatasii*. *Legs* very long, femur of hind pair nearly as long as the abdomen; tibia one and one-third times the length of the femur; tarsi longer than the tibiae by about one-sixth, or nearly as long as the wing; ungues simple. *Wings* (fig. 5) with the hind margin strongly arched; sixth longitudinal vein short, terminating near the centre of the hind margin, the length equal to the distance, in a straight line, from its tip to the tip of the third longitudinal vein; the anterior

branch of the second longitudinal vein twice the length of the distance between the two forks.

Length 2·50 mm.

The black or brownish-black colour of the integument of this insect will serve as a ready means of distinguishing it from any of its allies. It may also be separated from *P. papatasii*, to which it is closely related in its morphological characters, by the shape of the wing and the shorter sixth longitudinal vein. The only two examples which were secured were taken by Captain P. J. Marett; both are females, one of which bears the data: 'Black species, Gozo, 20, X, 10'; the other '*P. papatasii*, dark variety, 17, VI, 10, F.'

Captain Marett had evidently, therefore, noted the black or dark colour of this insect in life; and when questioned regarding this he was absolutely certain that the colour was not due to *post mortem* changes. It is undoubtedly a rare insect in the Maltese Islands, otherwise more specimens would have been secured. We trust that Captain Marett will be able to obtain examples of the males so that the characters of the armature may be examined and described.

PHLEBOTOMUS MINUTUS, Rondani.

Male.—*Colour.* Integument rather opaque, dull golden ochreous. Antennae with black and ochreous hairs mixed. Head with the clypeal and occipital tufts of hairs pale ochreous. Thorax with a median mane-like tuft, a lateral tuft in front of the insertion of the wings and also a tuft on the scutellum, all pale ochreous with a golden tinge, but with a few intermingled black hairs. Abdomen densely clothed with recumbent, dull, golden ochreous hairs; those covering the genital organs intermingled with black hairs. Legs covered with scales which appear smoky brown in some lights, silvery ochreous in others. Hairs of the wing mixed black and ochreous, those of the costa not darker than those on the surface of the wing.

Head. Proboscis relatively short; clypeus hairy. *Antennae* with the third segment a little longer than the fourth, but not nearly so long as the fourth and fifth together; the long verticillate hairs extending to the apical segment. *Palpi* (fig. 13) with the

second segment one-half the length of the third; the latter much the stoutest and broadest; dorsally it appears incrassate towards the base; fourth segment not quite so long as the third; fifth much the longest.

Wings (fig. 7) very narrow, and bluntly lanceolate; divided into two almost equal halves by the third longitudinal vein; the upper or anterior branch of the second vein shorter than the distance between the two forks.

FIG. 13.—Palpus of *Phlebotomus minutus*.

Legs. Hind pair a little more than three times the length of the abdomen inclusive of the genitalia; tarsus a little longer than the tibia.

External genitalia (figs. 14, 15) small; superior claspers with four long spines: two apical and two subapical: inferior claspers very slightly swollen in the middle; intermediate appendage similar to that in *P. papatasii*; intromittent organ nearly three-fourths the length of the inferior claspers; genital filament not protruding.

Length 1·5-1·65 mm.

FEMALE.—*Colour.* Wings with a distinct black costa and fringe; wing-area also with numerous black hairs intermixed with the ochreous ones. Legs with the femora ochreous beneath, darker above; tibiae and tarsi blackish, with silvery grey scales. Thoracic and abdominal hairs as in the male.

Antennae with the long hairs extending to the tip, the third to

the ninth segments, inclusive, with geniculated and paired spines. *Palpi* as in the male.

Length 2 mm.

The distinguishing characters of this insect are its relatively small size, especially in the male; the recumbent abdominal hairs; the short third antennal segment; and the marked character of the palpi. The male may be easily distinguished also by the form of the external genitalia.

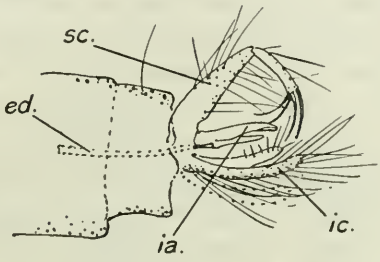

FIG. 14.—External genitalia of *Phlebotomus minutus*, ♂; *sc*, superior claspers; *ic*, inferior claspers; *ia*, intermediate appendages; *ed*, ejaculatory duct.

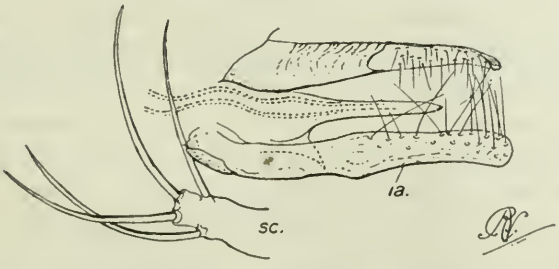

FIG. 15.—Superior clasper (*sc*) and intermediate appendages (*ia*) of *Phlebotomus minutus*, more highly magnified.

The first two examples were captured by Major F. L. Dibblee, Royal Marine Artillery, at his residence at Sliema, August 20th, 1910; and two additional specimens were taken by myself, one at Casa Leoni, in a rabbit hutch, August 31st; the other at Floriana, August 27th.

In captivity *Ph. minutus* is much more active than any of the other Maltese species, and when confined to a small area was almost incessantly moving from place to place. Apart from its flea-like actions it also has the remarkable habit of whirling round and round with great rapidity, so rapidly at times as to render itself almost invisible.

PHLEBOTOMUS PERNICIOSUS, n. sp.

MALE.—*Colour immediately after death.* Eyes black. Thorax with or without dull red-brown spots; when present they are arranged in a triangle, and there is occasionally a similar spot on the vertex of the head. Thorax and coxae pale, translucent ochreous; abdomen similar, but sometimes pale smoky grey. Hairs pallid. Wings faintly iridescent in strong light; pale drab in subdued light; costal fringe generally very dark or blackish grey, though examples with pale costal fringes are not uncommon. Legs silvery grey, in a strong light presenting a distinct metallic lustre; in certain lights also those segments which lie in shadow appear almost black and show up in marked contrast to those which are so placed that their surfaces refract the light. In some lights the under surface of the legs appears distinctly and regularly speckled, a character due evidently to the regular arrangement of the scales.

Head densely hairy, with generally two ill-defined tufts. Clypeus with a large tuft of hairs, some of which are directed forwards, others backwards towards the forehead.

Palpi with segments 2, 3 and 4 equal in length and collectively a little longer than the 5th. *Antennae* with the second segment much longer than the two succeeding ones; the longest hairs on segment 14 almost equal in length to those on the preceding segment. *Thorax* densely hairy, usually with a tuft on the front portion and another on the scutellum. *Abdomen* densely hairy, the longest hairs arising from the apical margin of the segments but no distinct tufts are found as in *P. papatasii.* The arrangement of the hairs is similar in both sexes, but blackish hairs are often intermixed with the pale ochreous ones on various parts of the body in the darker forms of this insect. *Legs* shorter than those of *P. papatasii.* *Wings* (fig. 6) with the posterior border much more strongly arched than the anterior border; the anterior branch of second longitudinal vein nearly as long as the stem between the cross vein and the proximal fork.

External genitalia (figs. 16, 17). Superior clasper with five very long stout curved spines; two apical, one external and two internal, placed a little in advance of the outer one; inferior clasper nearly twice the length of the intermediate appendage and clothed to the apex with very long and slender hairs; intermediate appendage

somewhat finger-shaped and hairy, proximal portion with a large keel-like extension ventrally, the distal margin of which bears several (5-6) hairs; apex of intromittent organ deeply divided or forked, with occasionally a minute central tooth; exposed portion of the genital filament about half the length of the intromittent organ.

FEMALE.—With the *palpi, antennae and legs* similar to those of the male. *Wings* very slightly larger and broader than those of the male.

Length 1·9-2·2 mm.

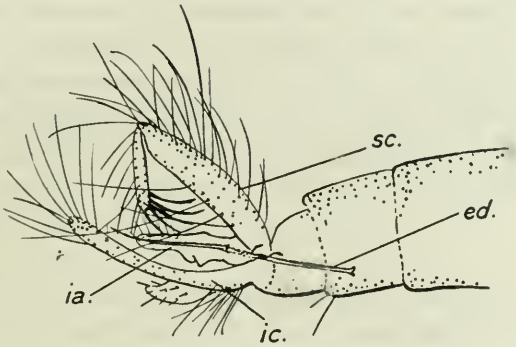

FIG. 16.—External genitalia of *Phlebotomus perniciosus*, ♂ ; *sc*, superior claspers; *ic*, inferior claspers; *ia*, intermediate appendages; *ed*, ejaculatory duct.

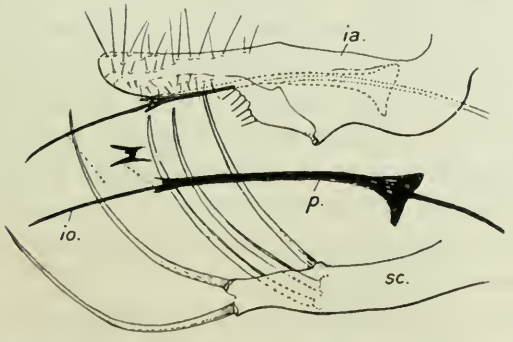

FIG. 17.—Portion of genitalia of *P. perniciosus*, ♂, more highly magnified; *sc*, superior claspers; *ia*, intermediate appendage; *p*, penis; *io*, intromittent organ.

This insect is widely distributed over the island of Malta, and was extremely abundant during the month of August and the beginning of September, though many examples were captured also in July. It was most abundant at Floriana, near the old bastion by the Grand Harbour, on the evenings of August the 26th and 27th,

when, between the hours of 8.30 p.m. and 9.30 p.m., thirty-nine examples were captured as they came into a lighted room; of this total twenty-eight were males and eleven females.

Two examples of *P. minutus* were found in association with this species; but strange as it may seem, not a single example of *P. papatasii* was either captured or seen on these occasions.

It was common also during the last week in August at Casa Leoni, the residence of the Hon. E. C. Roupell, D.S.O., Acting Lieutenant-Governor. In this place it was found most abundantly in a large outhouse which was tenanted by a number of rabbits. In the early mornings, shortly after 6 a.m., numbers of sand-flies were found chiefly in the corners of the room, but many were also seen sitting about the walls in various places, though chiefly at the junction with the ceiling. Later in the day they were rarely seen in these situations; but examples could always be found in the dark earthen pots which were used, and generally occupied by the rabbits as retreats.

The male is easily distinguished from that of *P. papatasii* by its generally smaller size, shorter legs, and much smaller genital armature, which is little more than half the width of the abdomen. The female may also be distinguished by its shorter legs, and generally darker colour. After a few hours in captivity it also becomes generally much less active than *P. papatasii*, though it has the same hopping flight so characteristic of these insects.

PUPA (Pl. VI, fig. 4).—Abdomen distinctly and sharply curved upwards so that a somewhat **S**-shaped outline is produced; thorax gibbose; abdominal segments each provided with a *pair of very large tubercles* (Pl. VI, fig. 5), the tips of which are furnished with a pair of broad flat appendages; integument thickly covered with squamose spines (Pl. VI, fig. 4).

The larval skin attached to the pupa does not present any morphological differences from that of *P. papatasii*, as far as one can gather from its shrivelled condition. It possesses the same kind of caudal bristles and hairy body-spines.

PHLEBOTOMUS PAPATASII (Scopoli)

Bibio papatasii, Scopoli. Deliciae faun. et flor. Insubriciae, I, p. 55, Pl. XXII, fig. B. a. b. (1786).

Cyniphes molestus, Costa, Storia dei lavori dell'Acad. Aspir. Natural., Artic. Zool. (1840); id., Annali dell'Acad. Aspir. Natural. I, p. 4 (1843).

Hermasson minutus, Loew (*nec* Rondani), Stettin. Ent. Zeit. V, p. 115, Pl. I, figs. 1-5 (1844).

Phlebotomus papatasii, Grassi, Mem. d. soc. Ital. d. Sci. (3) XV, p. 353 (1907).

This insect has been described so frequently that it seems unnecessary here to do more than add such particulars as have hitherto been overlooked, or imperfectly dealt with. In the first place it may be noteworthy to state that there are two distinct colour varieties of this common and widely distributed insect:—

(1) A uniformly pale form, which may be considered typical;

(2) A form which differs from the foregoing in having a dark coloured fringe to the costa and hind margin of the wing; herein described as the dark form.

FEMALE.—*Typical pale form* (immediately after death).—Almost uniformly pale translucent ochreous, thorax with a long dull red-brown median stripe, and a single spot of the same colour on either side, near the front margin of the thorax. Hairs on all parts of the body greyish, their arrangement similar to that of the male. Wing relatively broad (fig. 4). Wing fringe not markedly darker than the hairs on the disc of the wing.

MALE.—*Typical pale form* (immediately after death).—Colour similar to that of the female. Clypeus with a tuft of eight to ten hairs; head with a loose tuft, some of the hairs curving forwards, others backwards; tuft on nape of slightly longer ones, chiefly curved forwards. Thorax densely clothed; the hairs arranged in loose tufts. Wing much narrower than in the female (fig. 4). Abdomen uniformly hairy, with small tufts on the dorsum arising from the apical margin of each segment; superior claspers densely hairy, with a few black hairs intermixed with the pale ones; these hairs are easily deciduous, with the exception of a large tuft which is more or less permanent in examples mounted in Canada balsam.

FEMALE.—*Dark form.*—General colour similar to that of the pale form. Wing fringes distinctly smoky grey; some of the hairs on the veins are also dark grey or smoky grey.

MALE.—*Dark form.*—Not observed.

This form is not uncommon; but is very much rarer than the dark form of *P. perniciosus*. It does not differ structurally from typical pale examples so that the following description of the palpi and antennae applies to both varieties.

Palpi of five segments; 1 very short, slightly dilated distally; 2 a little longer than the succeeding one; 3 decidedly broader than the rest; 4 a little shorter than 3; 5 as long as or slightly longer than 2; 1 to 3 hairy; 4 and 5 scaly and with a few fine hairs. *Antennae* (fig. 2) of sixteen segments; 1 and 2 the stoutest, the former with one side longer than the other, the latter bead-like; 3 much the longest, being equal in length to the last five segments together; 4-13 each very slightly shorter than the preceding one respectively; 14 to 16, inclusive, more strongly incrassate (swollen) basally than the rest; all the segments with the exception of 1 and 2 densely clothed with hairs, the longest of which arise from the incrassated portion of each segment, except on the terminal segments which are furnished with hairs of equal length; 4 to 15, inclusive, also furnished with a pair of stout spines (fig. 2), which are suddenly elbowed or bent at right angles to their insertion so that for nine-tenths of their length they lie practically parallel with the surface of the segment to which they are attached.

The external genitalia of the male are much larger than those of any of the other Maltese species; a character which may be readily recognised in life, under a low magnification. The morphological characters are shown in the accompanying illustration (fig. 18). Length, 2·5-2·65 mm.

In captivity this insect is much more restless than *P. perniciosus*, so much so that after a few hours one may readily distinguish the two species by this alone, apart from the other characters; *i.e.*, the generally larger size, paler colour, and much longer legs of *P. papatasii*.

Ovum (Pl. V, figs. 1-5). When forcibly expelled from the body a day or so before the cuticle has become opaque the interior (oolemm) can be seen; and in such examples also the micropyle is distinctly visible as a short ring-like extension at the anterior pole of the egg. The oolemm at this stage is filled with globular particles of fatty matter, suspended in a structureless matrix. When first laid the egg is translucent white and covered with a thin

coating of viscous matter by which it readily adheres to the surface upon which it may fall; five hours after it has been laid it assumes its normal form and colour, which may be described as follows:— Form very elongate, dark brown, shining, with longitudinal black wavy lines, which in certain lights give the periphery of the egg a faintly rugose appearance; these black lines are slightly raised and are joined by slender cross-lines so that a faint but rather coarse reticulation is formed. The transverse lines are, however, very difficult to trace unless they are illuminated by a strong beam of light.

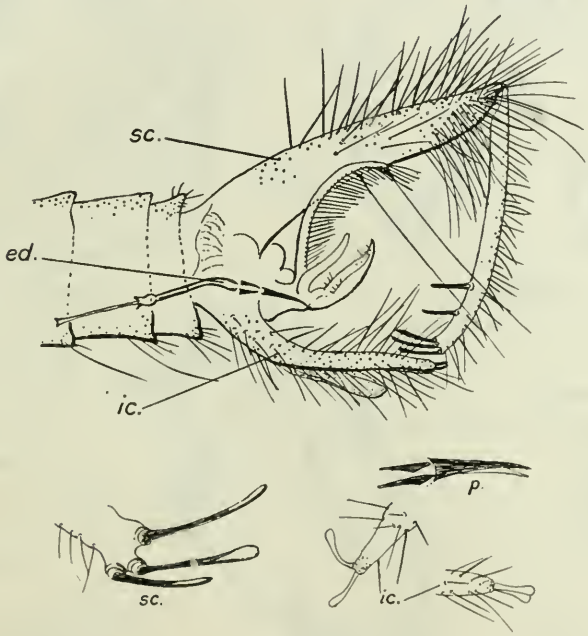

FIG. 18.—External genitalia of *Phlebotomus papatasii*, ♂; *sc*, superior claspers; *ic*, inferior claspers; *ed*, ejaculatory duct; *p*, penis.

The incubation period lasts for about nine days; but unless kept in a moistened atmosphere the eggs will not hatch.

LARVA.—First instar (Pl. V, fig. 8). Cylindrical and distinctly caterpillar-like in its general form; head black; body white or ochreous white; caudal bristles, long, black. Head (fig. 19) very broadly pyriform; frontal hairs two in number; simple; dorsally there are three similar hairs on each side; one arising from the mid-region of the mandibles, one near the base; and a slightly

longer one towards the centre of the head, near the margin; besides these there are at least four hairy spines on each side, arranged as shown in the illustration. Antennae (fig. 19, *ant.*) composed, apparently of three segments, the first two being quite rudimentary and ring-like; third segment broad, flat and ovate in outline, the

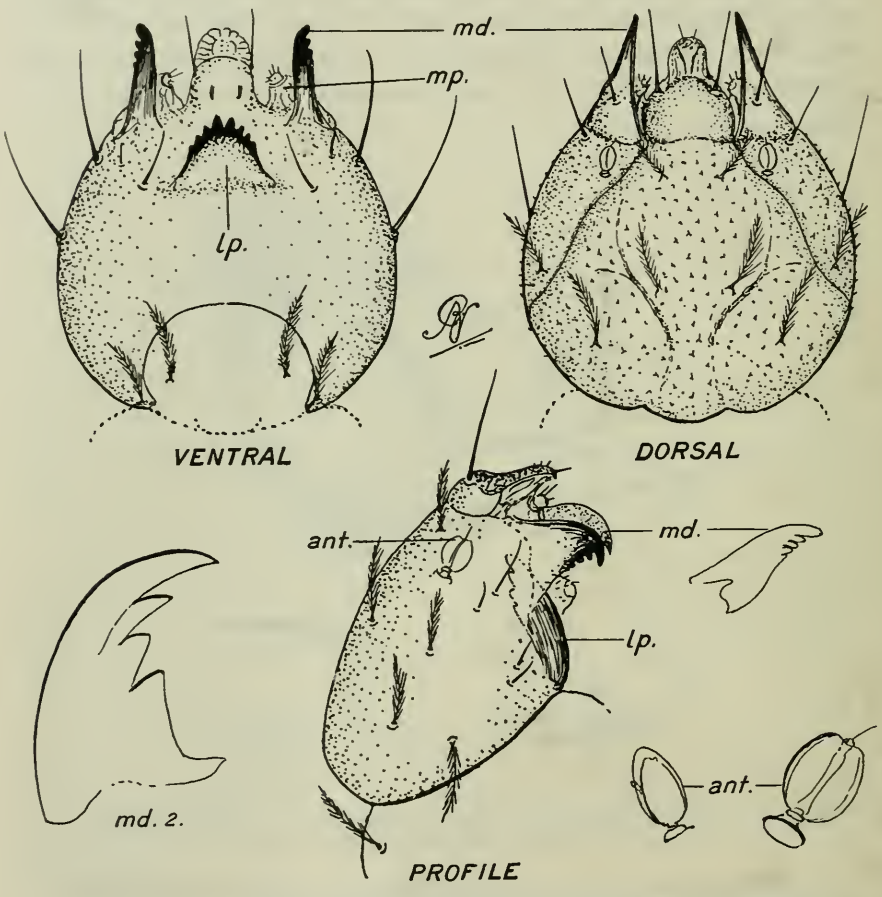

FIG. 19.—Head of larva of *Phlebotomus papatasii*. *ant*, antenna; *md*, mandible; *mp*, maxillary palpus; *lp*, labial plate.

anterior edge faintly emarginate and furnished with a centrally placed hair. Mandibles (fig. 19, *md.*) large and provided with four distinct but rather blunt teeth, of which the apical one is much the largest. Labial plate (fig. 19, *lp*) somewhat triangular in outline with four teeth on each side, the median ones being much the

largest; in its general form the labial plate resembles those found in the larvae of the CULICIDAE. Articulations of the body clearly defined; each segment bears from four to five hairy spines on each side, all of which are broadly dilated apically. Caudal bristles in two pairs, one of which is much the longer, almost equalling the length of the body, the other pair are extremely short.

Last instar (Pl. V, fig. 7). Form resembling that of the first instar; colour pale ochreous white; head black; caudal bristles black, arranged in two pairs, each pair being attached to a large tuberculous process; the inner bristle is much the longer, almost equalling one-half the length of the body of the larva; all of these bristles, under a high magnification, present a number of extremely fine, equidistant, and intensely black surface lines, the intervening spaces being distinctly pale; it is highly probable therefore that these bristles are finely striated, but as no sections were cut it is impossible to determine their true structure by examining them in optical section only. Thoracic and abdominal spines (Pl. V, fig. 10) much longer and stouter than those in the earlier stages; apices *narrowly dilated* and transparent, the remaining portion clothed with minute stiff hairs; these hairy spines are arranged in more or less regular transverse rows, there being four or five on each side of the median line. Head with several large spines similar to those on the abdominal segments, but they are pointed instead of being dilated at the apex; besides these hairy spines there are also several rather long stout hairs, four of which are frontal. Sucker feet similar to, but relatively larger than those in the first instar.

Length 2-3·28 mm.

PUPA.—(Pl. V, figs. 11, 12).—When empty, clear ochreous buff. Eyes in life black. Abdomen curved upwards distally in varying degrees, but not apparently so distinctly **S**-shaped as in *P. perniciosus;* considerably wider in the thoracic region than at the distal segments of the abdomen; integument clothed with minute squamose spines (Pl. V, fig. 15), which are most conspicuous on the abdominal segments. Thorax with two tubercles on each side, the anterior one bearing two or three long slender spines. Abdominal segments each with one (possibly two) extremely minute tubercles at the apex of which is a minute broad flat spine; those on the 7th

and 8th segments more conspicuous than the rest; but all of these processes are so minute as to be easily overlooked. Wing-sheaths pointed apically and extending subventrally as far as the base of the 7th abdominal segment. Head distinctly elongated and somewhat triangular in outline; in the empty pupa this often breaks away in the process of mounting when the outline may be seen to bear a striking resemblance to the head of an ox in miniature (Pl. V, fig. 13). Antennal sheaths distinctly segmented, lying curved behind the eyes and subsequently following the costa of the wing-sheath. Palpal sheaths originating near the centre of the frons, extending backwards and then curving suddenly forward so that the apex rests against the antennal sheath and lies pointing in the same direction. Legs extending slightly beyond the wing sheaths.

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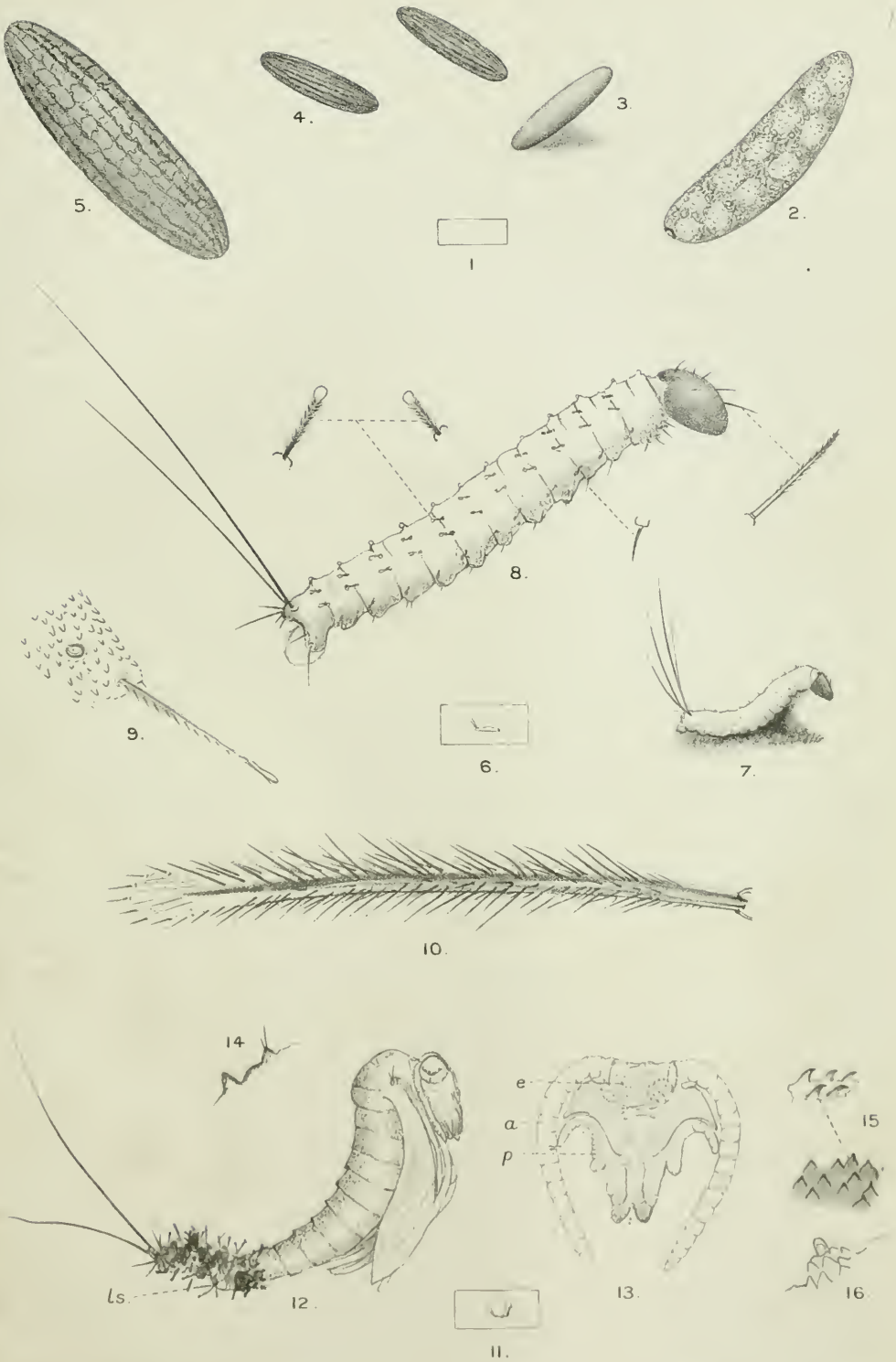
PLATE V

Phlebotomus papatasii, Scop.

Fig. 1. Eggs, approximately natural size.
2. Egg, a few hours before extrusion, showing micropyle.
3. Egg, freshly extruded.
4. Egg, a few hours after extrusion.
5. Egg, much enlarged, to show reticulated surface.
6. Larva, approximately natural size.
7. Sketch of adult larva, enlarged.
8. Larva; first instar, enlarged.
9. Stigma of larva with spine.
10. Hairy spine of larva.
11. Pupa, approximately natural size.
12. Pupa enlarged: *ls*, larval skin with anal bristles attached.
13. Front view of the head of the pupa: *e*, eye; *a*, antenna; *p*, palpus.
14. Thoracic tubercles of pupa.
15. Squamose body-spines of pupa.
16. One of the abdominal papillae of the pupa.



R. Newstead, *ad. nat. del.*

Bale & Danielsson, Ltd., *lith.*

PHLEBOTOMUS PAPATASII

PLATE VI

Phlebotomus papatasii, Scop.

Fig. 1. Imagos, approximately natural size.
2. Male, enlarged; from life.

Phlebotomus perniciosus, Newst.

3. Pupa, approximately natural size.
4. Pupa, enlarged.
5. One of the abdominal tubercles of the pupa.
6. Squamose spines of the abdominal segments of the pupa.

2.

1.

6.

4.

5.

3.

R. Newstead, *ad. nat. del.*

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PHLEBOTOMUS PAPATASII AND P. PERNICIOSUS.

PLATE VII

Fig. 1. *Phlebotomus papatasii*, Scop., female, enlarged; from life.

2. *Phlebotomus perniciosus*, Newst., female, enlarged; from life.

3. *Phlebotomus perniciosus*, approximately natural size.

[Note.—The above enlarged figures and that of the male shown on Plate VI are all drawn to the same scale.]

1.

2.

3

R. Newstead, *ad. nat. del.* Bale & Danielsson, Ltd., *lith.*

PHLEBOTOMUS PAPATASII AND P. PERNICIOSUS.